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Technical activity from July 1 through September 30, 1966 was concentrated on (1) completion of materials, staff training, and implementation arrangements for the junior high guidance program, (2) development of measures for assessing student achievement of instructional objectives, and (3) design of learning units for the curriculum. This report presents the problems, procedures, and principles of developing learning units. The detailed procedures used to specify topics and learning units vary in some aspects from one type of course to another. The procedural variations are described for specific vocational, mathematics and science, social studies, and English courses. The design of learning units is a problem in selecting and arranging the elements and events of the learner's environment so that their effects include the acquisition of the desired capabilities by the learner. Eight functions which must be performed by the instructional situation are described. Unit content is organized into objective, overview, learning experiences, summary, references, learning aids, and evaluation. An example of the learning unit plans and the checklists used to survey jobs for requirements of mathematics and science skills and knowledge are given in the appendixes. Other reports are available as VT 001 392-001 397, VT 004 848, and ED 013 318. (HC)

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SIXTH QUARTERLY TECHNICAL REPORT

Project No. 5-0009

Contract No. OE-5-85-019

DEVELOPMENT AND EVALUATION OF AN EXPERIMENTAL CURRICULUM FOR THE NEW QUINCY (MASS.) VOCATIONAL-TECHNICAL SCHOOL

The Development of Learning Units

30 September 1966

U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Research

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American Institutes for Research
Pittsburgh, Pennsylvania

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FOREWORD

This report, submitted in compliance with Article 3 of the contract, reports on technical activities of Project ABLE during its sixth quarter of operation, 1 July through 30 September 1966. A brief overview of the project is presented first, followed by a report summary. The major portion of the report is a discussion of the development of learning units by which students acquire the capabilities that are the objectives of instruction.

OVERVIEW: Project ABLE

A Joint Research Project of: Public Schools of Quincy, Massachusetts and American Institutes for Research

Title: DEVELOPMENT AND EVALUATION OF AN EXPERIMENTAL CURRICULUM FOR THE NEW QUINCY (MASS.) VOCATIONAL-TECHNICAL SCHOOL

Objectives: The principal goal of the project is to demonstrate increased effectiveness of instruction whose content is explicitly derived from analysis of desired behavior after graduation, and which, in addition, attempts to apply newly developed educational technology to the design, conduct, and evaluation of vocational education. Included in this new technology are methods of defining educational objectives, deriving topical content for courses, preparation of students in prerequisite knowledges and attitudes, individualizing instruction, measuring student achievement, and establishing a system for evaluating program results in terms of outcomes following graduation.

Procedure: The procedure begins with the collection of vocational information for representative jobs in eleven different vocational areas. Analysis will then be made of the performances required for job execution, resulting in descriptions of essential classes of performance which need to be learned. On the basis of this information, a panel of educational and vocational scholars will develop recommended objectives for a vocational curriculum which incorporates the goals of (a) vocational competence; (b) responsible citizenship; and (c) individual self-fulfillment. A curriculum then will be designed in topic form to provide for comprehensiveness, and also for flexibility of coverage, for each of the vocational areas. Guidance programs and prerequisite instruction to prepare junior high students also will be designed. Selection of instructional materials, methods, and aids, and design of materials, when required, will also be undertaken. An important step will be the development of performance measures tied to the objectives of instruction. Methods of instruction will be devised to make possible individualized student progression and selection of alternative programs, and teacher-training materials will be developed to accomplish inservice teacher education of Quincy School Personnel. A plan will be developed for conducting program evaluation not only in terms of end-of-year examinations, but also in terms of continuing follow-up of outcomes after graduation.

Time Schedule: Begin 1 April 1965

Complete 31 March 1970

Present Contract to 30 June 1967

REPORT SUMMARY

During the present reporting period, technical activity concentrated on (1) completion of materials, staff training, and implementation arrangements for the junior high guidance program and start of the program in all junior high grades, (2) development of measures for assessing student achievement of instructional objectives, and (3) the design of learning units for the curriculum. The present report is devoted to the problems, procedures, and principles of developing learning units. It reviews the process whereby learning units necessary to the achievement of objectives are identified, describes the principles and methods for the design of learning units, and discusses some implications of the resulting curriculum for the teaching and administrative functions.

During the next quarter, the design of learning units and the related measures of achievement will constitute a major portion of the technical activity. In addition, procedures for evaluation of the junior high guidance program will be devised, development of senior high guidance objectives will continue, and the Advisory Panel will meet to review products and to consider the problems of implementing the program.

THE DEVELOPMENT OF LEARNING UNITS

A curriculum may be defined as an organized sequence of instructional situations. If the objectives of the curriculum are defined in terms of performance capabilities desired of graduates, and they are so defined in Project ABLE, then the task of curriculum development is to design and order a set of instructional situations by which students acquire those capabilities efficiently. The total development process involves many interacting activities (Taba, 1962) which have been summarized for Project ABLE in the project planning documents (American Institutes for Research and Quincy Public Schools, 1964; Morrison, 1965a). The present report will emphasize one portion of the process: the derivation and design of instructional situations or learning units of the curriculum.

The first section of the report provides a summary of the procedure for arriving at objectives for courses, describes the methods for defining topics and learning units in support of those objectives, and examines some results of the procedure. The second major section describes the learning units being developed and discusses their salient characteristics. Finally, there is an examination of the effects of such units on the role of the teacher and on the administration.

Identification of Learning Units

The general plan for deriving objectives, described in detail in earlier reports (Morrison, 1965a; Morrison, 1965b; Morrison & Gagné, 1965), was analytic and selective. We began with general goals for graduates: vocational competence, responsible citizenship, and self-fulfillment. These long-range goals were restated in terms of performance capabilities which could be acquired and demonstrated by students and which could serve as terminal objectives for the curriculum. Each major objective then was analyzed into those component capabilities a student must possess as prerequisites to learning the terminal capability. Each of these prerequisite

capabilities also had prerequisites which could be identified; so the process of repeatedly analyzing capabilities for their prerequisites could generate a hierarchy of capabilities extending from the complex curriculum objective at the top to the simplest of capabilities at the bottom.

At the outset of this process in Project ABLE, our major emphasis was on comprehensiveness. Our purpose was to generate a map of the total domain of potential objectives for each goal of the curriculum. However, it soon was apparent, as indeed it had been from the start, that no curriculum could include as objectives all of the capabilities which were being identified by this process. Selection of objectives was necessary both among different areas of the curriculum and within them. The analytic procedure greatly clarified the selection task, however, since the available choices were explicit at each level in the developing hierarchy of potential objectives.

A tentative selection of objectives for the curriculum was made and a plan was described for organizing the selected objectives into courses (Morrison & Gagné, 1965). With these decisions taken, it then was possible to continue the analytic procedure, to specify topics in support of the selected course objectives, and to begin designing the instructional units by which students could acquire the desired capabilities.

Parenthetically, the should be noted that the objectives derived from the general goals were regrouped when organizing courses. Thus, there is no course in responsible citizenship. Objectives deriving from the domain of citizenship are to be found in social studies courses primarily, but also in English courses to some extent. Some general vocational capabilities are objectives of the guidance program and others are in the vocational courses. Preparation for "specific" vocational objectives is found in several "academic" courses as well as in the specifically vocational courses. The strategy was first to define the outcomes desired and then to organize the preparation for these outcomes in pedagogically sound and practical groupings, using existing course arrangements where reasonable and adding courses where necessary.

The detailed procedures being used to specify topics and learning units vary in some respects from one kind of course to another, though the general procedure is the same. These procedural variations are described in the following paragraphs.

Specific vocational courses. The procedures for deriving objectives and choosing a curriculum led to the selection of 11 vocational areas. Within each vocational area, a number of jobs were selected for inclusion in the training program. Among the criteria for selecting jobs were two of particular relevance to this discussion: (1) jobs in each area were chosen in sets which defined skill-career progressions, and (2) jobs were chosen so that they collectively included the major capabilities of the whole vocational area. These criteria make it possible to develop training in which a student may acquire capabilities in a sequence which qualifies him for progressively higher-level jobs and emerge from training with capabilities appropriate for a variety of jobs in his vocational area.

Each of the more than 250 jobs selected for the training program was analyzed carefully (Morrison, 1965a). The analysis included enumeration of the tasks actually performed by workers in the job and provided other data such as entry qualification requirements, environmental conditions, and contingencies. Course objectives, based on the task and related data for each job, were stated as performance capabilities which must be acquired by the student to satisfy entry requirements. Each course objective then was analyzed into its component capabilities, called topics, and a hierarchy of objectives, prerequisite to the course objective, was defined (Morrison & Gagné, 1965). The total hierarchy, with the course objective at the top and the simplest capabilities at the bottom, will provide an organized list of the learning units through which the student could proceed to acquire the capability defined as an objective of the course.

Mathematics and science courses. Objectives for these two sets of courses derive primarily from analysis of the goal of vocational competence. Identification of objectives for mathematics and science began with an analysis of objectives in the vocational areas for prerequisite mathematical and scientific capabilities. A detailed checklist of skills and knowledges

was prepared for each of the two subject areas (See Appendix A). These checklists were used by the vocational specialist and the "academic" specialist to identify capabilities as essential, desirable, or unnecessary for the jobs in his area. Data collected from all vocational areas were consolidated. It then was possible to identify a "core" content required for nearly all job sequences and also to define several subsets of additional capabilities, each of which was appropriate only for some job sequences. The topics selected by this procedure provide the minimum content for courses in mathematics and science.

While vocational requirements supply a major portion of the demand for topics in mathematics and science, a few topics appear in response to the goal of responsible citizenship. Thus, for example, no vocational area requires any capability with respect to the concepts of nuclear physics. Yet, nuclear energy is a matter of important concern to today's citizen, so some elementary units in this material hopefully will be included. Several topics in biology are included on the same basis. Of course, many topics included first for vocational reasons also serve the goal of responsible citizenship and the goal of self-fulfillment as well.

Many of the topics being selected for mathematics and science are of a size appropriate as learning units for students with the expected entry capabilities. Some topics are more complex and must be analyzed into their components which are appropriate as learning units. In any case, the learning units are being identified by the familiar process of analyzing selected terminal performance capabilities for their prerequisite capabilities.

Social studies courses. Objectives for social studies courses derive primarily from analysis of the goals of responsible citizenship. The domain of citizenship objectives was mapped originally by a three-dimensional scheme. One dimension was a list of the kinds of behavior in which one could engage in his role as citizen. A second dimension was a list of societal problems with respect to which the behaviors could be taken. The third dimension was a list of societal levels at which behavior could occur with respect to a problem. Each cell of this three-dimensional figure contained potential objectives involving those kinds of behavior relevant to a

particular problem (or societal goal) in a particular societal organization. Thus, one cell might contain specific objectives related to petitioning the local government on a matter of public education. Another cell might contain objectives related to using systematic procedures in arriving at a solution to an international economic problem. Even at this gross level of analysis, it was clear that only a very limited portion of the very large domain of citizenship objectives could be included in the curriculum.

The problem of selecting course content was undertaken by the project staff who were counseled by the Advisory Panel and by members of the Quincy faculties and administration. Numerous considerations had some weight in the final selections. The probability that graduates would have opportunity to exercise a particular kind of behavior with respect to a problem at a given societal level was a major concern. So also were such factors as the current offerings in pre-high school courses, the judgment of authorities in related disciplines as to the relative importance of various topics, the state requirements for high schools graduation, and the internal consistency of the curriculum. The solution finally adopted was to emphasize rational decision making, one important kind of behavior in the original map, as the organizing principle of the courses. Students would learn this process and apply it to a variety of problems at three societal levels: large groups, small groups, and individuals. The selection of specific topics is being based on staff judgment, with the aforementioned counsel, as to the relative importance of the topics to graduates' needs as citizens. A particular effort is being made to include questions and problems which are current in the students' present world.

Because the domain of citizenship objectives is vast and because selections often must be made among equally justifiable alternatives without the relatively neat performance reference readily available in vocational areas, the selection of topics and the development of learning units in social studies depends more upon staff value judgments than do units in vocational areas. However, topics are being selected in a systematic, explicit way in accordance with the analysis of responsible citizenship.

English courses. Unlike the courses discussed previously, English courses derive their content from all three of the broad goals of the curriculum (Morrison & Gagné, 1965). The analysis of vocational satisfaction included general vocational capabilities, which in turn yielded a sub-domain of seven kinds of knowledge basic to a wide variety of occupations (Altman, 1966). One of these seven, verbal communication, provided objectives judged handled best in the English course. A second area, human relations, provided possible topics for a study of literature. Analysis of the goal of self-fulfillment identified literature as a major vehicle for continuing self development. Finally, it was recognized that literature provides a primary source of information and ideas about problems of consequence to citizens and about the role of the individual in society.

Any one of the above implies a set of objectives which is more than enough for a full and demanding course of study in English. It is necessary, therefore, to select objectives and topics from the large number available for English just as it is necessary for all other curriculum areas. The project staff, again counseled by the Advisory Panel and by their Quincy colleagues, selected and organized a set of topics collectively relevant to the needs of graduates with respect to all three curriculum goals. Two kinds of units are being prepared in support of these topics. One set of units is devoted to development of language skills. They constitute a sequential program designed to produce capable verbal communication. This sequence provides more than the usual amount of instruction and practice in composition. The compositions and study of verbal communication are planned to include subjects and types of communication related to the students' vocational and everyday needs as well as to the work in literature. The units in literature are organized thematically and approximately parallel the sequence in social studies. Thus, one set of units deals with man and his environment (problems posed by social or natural environment); a second set concerns man's behavior (as a member of society and in response to personal challenge); and a third set investigates the inner nature of man (personal identity). The attempt is being made to select readings which deal with real and persistent problems of concern to the students,

which present a variety of types of literature, and which are at once "good" literature and interesting reading for people of high school age. For citizenship, the literature sequence is being designed to offer answers to the question: "How do I relate to the community and to other persons?" For self-fulfillment, it is intended to provide answers to the question: "Who am I, and what are the potentials that lie within me as a human being?"

As in social studies, the initial selection of objectives for English had to be made early in the analysis and at a relatively gross level because of the very large number of potential objectives. Further, except for those communication skills which can be derived from analysis of job task requirements, the precise performance reference is not easily defined empirically. The judgment of the staff and their consultants necessarily plays its largest role in the identification of objectives, topics, and learning units for English. Even so, application of the general analytic procedure to curriculum goals produced organized and relevant classes of objectives from which the solution for English courses could be made rationally.

Some results of the procedure. The general analytic procedure prescribed at the outset for deriving objectives and learning units from general goals has been followed in Project ABLE with the noted variations in detail. Work with the procedure has just entered the last phase of the process wherein learning units are being defined and developed in support of selected objectives. Yet, experience to date verifies our anticipation that several kinds of valuable results are available from this method of developing curriculum.

Perhaps the most easily recognized result is the relevance of instructional units to curriculum goals. So long as the procedure is followed, relevance is guaranteed because the analysis produces as potential objectives only those which are prerequisite to the goals. No matter how selective one must be, and no matter the judgmental basis upon which selections are made from the domain of objectives, the resulting curriculum content is relevant to the original goals.

Since it is virtually certain that the analysis will produce many more specific objectives than any curriculum can contain, a second result of the process is that the final set of instructional units is determined by judgment of the curriculum designer. This does not mean that the designer has freedom to include topics and instructional units chosen capriciously. Quite the contrary. As indicated in the preceding paragraph, the analysis limits choice to those objectives (and, therefore, those learning units) which are relevant to curriculum goals. But our experience is that there frequently is considerable room within the available choices for the exercise of judgment. This seems a desirable result since it permits the designer to respond in his curriculum to current needs of the students as he knows them. As a corollary result, the curriculum could be modified appropriately in response to changing student needs by changing the original selection to another objective also relevant to the curriculum goal.

The repeating process of analyzing the terminal objective into its prerequisite capabilities and then analyzing each of those capabilities into its prerequisites, and so on, produces a hierarchical structure of objectives. The curriculum that is chosen maintains the hierarchical relationships, and thus the procedure produces an organized curriculum outline. Within the hierarchy supporting an end objective, the essential sequence of learning is defined. Since the process is a rational one, the sequence it produces must be checked empirically (Gagné, 1966; Morrison & Lecznar, 1966). But it is a valuable result to have a defensible first organization of content directly available from the curriculum development process.

Having reviewed the procedures for identifying the units of the curriculum and having noted some major results of using this procedure, we turn to the design of instructional situations.

Design of Learning Units

The design of learning units, or instructional situations, is a problem in selecting and arranging the elements and events of the learner's environment so that their effects include the acquisition of the desired capabilities by the learner. The problem can be cast as an analogue of the problem

of designing a "black box" (instructional situation) which accepts certain inputs (student capabilities and characteristics), performs specified functions which transform the inputs, and thus provides the desired outputs (learned capabilities). The analogy is not perfect, but it is a fascinating one and a powerful tool. Without pursuing the analogy systematically, we may note some of its important implications for design of instructional "black boxes."

1. Inputs are expected to vary and the box is expected to tolerate some variation while still producing the desired outputs. Instructional situations are expected to accommodate some variation in students' starting capabilities. They are more valuable as they are able to tolerate greater variation.

2. No box is expected to tolerate unlimited variation in inputs. When inputs are outside acceptable limits, the box cannot produce acceptable outputs. An instructional situation cannot be expected to produce the desired capabilities unless learners enter with the prerequisite capabilities.

3. The system of which the box is a part must detect out-of-tolerance inputs and either reject them as inputs or pre-process them to produce inputs acceptable to the box. The instructional system must include assessment of the learner's entering capabilities. Those found deficient in prerequisite learning must be routed through other situations designed to produce the necessary capabilities.

4. Usually, there are many different boxes which can perform the desired transformation. Any box which performs the necessary functions is a solution to the design problem. Many different selections and arrangements of instructional conditions are capable of producing the desired learning. The essential requirement is that necessary functions be performed.

5. Not all solutions are equally efficient with respect to time, cost, error, or other important commodities. The most efficient acceptable solution is to be preferred. Instructional situations should establish conditions for efficient learning.

6. Outputs can be expected to vary as a function of input variations and as a function of operational variations in the box. Outputs are monitored for out-of-tolerance values. When detected, an out-of-tolerance output either is rejected or processed to produce an acceptable value. The learner's acquisition of the desired capability must be assessed after passing through the instructional situation. If found deficient, the learner must be routed through situations intended to remedy his particular deficiency.

7. In some cases, it is possible to monitor the output of the box and to use variation in the output to adjust the functions of the box so as to produce more acceptable outputs. The capabilities and deficiencies of students upon completion of the learning unit may be analyzed for implications for change in the instructional situation.

This simple adaptation of hardware design thinking to educational design is not intended to be complete or to argue that engineering holds the answers to educational problems. It is presented as a way to indicate a point of view: that the design of instructional situations can be approached effectively as a problem in providing for the performance of certain functions which transform a class of learners from one state to another with respect to their capabilities.

Component functions of the instructional situation. Eight functions which must be performed by the instructional situation have been identified and described by Gagné (1965). These functions are required no matter what arrangement of objects, events, and relations are selected for the

instructional situation. They are the ways in which the environment exerts its effects on the learner. The functions are reviewed below, relying heavily on Gagné's account, before turning to a description of learning units in Project ABLE.

1. Presenting the stimulus.

No matter what is to be learned, a stimulus is required. Usually, the stimulus must appear outside the learner, but within the instructional situation. The design of the instructional unit must provide for presentation of a stimulus appropriate for the type of learning expected. Thus, for example, if a concept is to be learned, a suitable variety of objects or events representing the class must be displayed. Appropriate stimuli can be presented in many different ways through various media; the design task requires that at least one way be provided.

2. Directing attention and other activities.

The environment must direct the learner's attention to certain stimuli or to certain aspects of stimulus objects and events. It also may be necessary to direct the learner to perform other activities such as recalling, estimating, listing, comparing, etc., which are not themselves learning. Such actions simply create proper conditions for learning. Written or spoken instructions are common means for directing the learner to these activities, though other techniques sometimes are preferable.

3. Providing a model for terminal performance.

The learner must be informed as to the performance capability he is to acquire. This function of the instructional environment is an important factor in motivation. Knowledge of the goal enables the learner to direct his activities toward a specific objective, to monitor his progress and identify specific deficiencies, and to recognize his achievement of the goal. The appropriate model for an instructional unit is determined by the kind of learning required. Probably, the two most common ways to provide a model are through verbal description and through demonstration of competent performance.

4. Furnishing external prompts.

In some instances, temporary cues may be needed to assist in learning. As learning progresses, these extra cues are dropped from the instructional situation. Such prompts take many forms, but always serve the function of facilitating the establishment of connections. The prompting cue for a sequence of responses or events might be a listing in sequence from top to bottom on a page. The cue for a concept might be provided by temporarily exaggerating or otherwise marking the defining attributes of examples of the class. Whatever prompts are needed, the design of the instructional situation must provide for them.

5. Guiding the direction of thinking.

When principles are being learned, and particularly when learning takes the form of problem solving, instructions may function to guide the direction of thinking. This kind of guidance is presumed to increase learning efficiency by reducing the occurrence of irrelevant hypotheses. It may be provided by verbal hints, suggestions, and questions, or even by visual and auditory conditions.

6. Inducing transfer of knowledge.

Education and learning usually are intended to accomplish more than simply to produce a specific performance. Normally, it is expected that the capabilities acquired will transfer to other situations and enable the learner to do things which were not directly learned, but which are similar to those that were learned. Instruction may be arranged to facilitate the transfer of concepts and principles to novel situations. By providing for practice or application of the capability in a variety of situations, the base for the capability may be increased and the probability that it will transfer to novel situations also may be increased.

7. Assessing learning attainments.

The learner's environment also functions to assess the extent to which he has achieved the learning objective. Frequently, it is possible for the student to make an assessment, but for an objective demonstration of his learning achievement, it is necessary that he be placed in representative problem situations which require exercise of the learned capability.

The important concern here is that the test situations accurately represent the stated learning objective.

8. Providing feedback.

The instructional situation must provide the learner with prompt information about the correctness of his responses during learning and in assessment of learning achievement. The effective means for providing this feedback are various in any situation, but the critical requirements for effectiveness are clarity and promptness.

These eight functions are the external conditions which bring about the desired changes in a learner who has the prerequisite capabilities.

With the essential functions identified, we turn to a description of the learning units by which Project ABLE is attempting to provide these functions.

Plan, content, and format. In one sense, each unit is unique. It has a unique objective and its own arrangement of instructional modes, media, and events designed to produce achievement of the objective. It is a design product in its own right and should be evaluated independently. This report cannot mediate such an evaluation. What it can do in the following paragraphs is describe the strategy, techniques, and requirements which have been applied in developing units and illustrate the results with example units.

A learning unit is defined by a set of materials. These materials include all that is needed by the student and the teacher to establish and conduct the learning activity. There must be a written plan for the unit which prescribes the sequence of events and provides directions. All information and objects including aids, equipment, and media needed for the prescribed activity also must be provided as part of the materials package. Ideally, a completely new package might be developed for each unit to ensure that the unit was maximally effective. Practical limitations on time and funds have required a different strategy in Project ABLE. Our intention has been to use existing materials as much as possible by incorporating them in lesson plans with such introductory, transitional, and

summary material as might be required. Of course, new assessment exercises and procedures must be prepared in most instances.

The lesson plan or guide is the key to learning units in Project ABLE. It is expected that the student or the teacher, whichever is appropriate, will use this document as his adequate guide to successful completion of the intended learning activity. While the format of learning units varies in detail somewhat, a generally applicable outline of the content of the units is as follows.

1. Objective.

This is a brief statement of the learning objective for the unit. It describes what the student should know or be able to do upon successful completion of the unit. Sometimes this is a restatement of a topic objective. It may be an objective subordinate to a topic objective. In either case, it functions to provide a verbal description of the terminal performance.

2. Overview.

This short introduction to the learning activity is intended to indicate the importance of the unit and the relations between the objective and the learning activities. It functions to define the relevance of the activity and contribute to achievement motivation.

3. Learning experiences.

This is the section which directs the learning activity. The student or teacher is expected to achieve the learning objective by following the indicated sequence of activities. In our units, an activity may be described here, if it is newly developed. Frequently, however, the student or teacher is given instructions with respect to materials in some other source (e.g., reading material, experiments defined in a workbook, films, charts, machines, instructor, etc.). This section of the lesson plan must bear principal responsibility for the functions of presenting the stimulus, directing the learner's activity, furnishing prompts, guiding the direction of thinking, and inducing transfer.

4. Summary.

This is a brief review of the unit which also indicates the relations between this unit and the next one.

5. References.

The printed materials used in the learning activity are identified here together with any other references to which the student might wish to refer for additional information relevant to the content of the unit.

6. Learning aids.

All materials other than printer matter are identified and listed. These include film strips, cutaways, simulators, raw material, machines, tools, etc.

7. Evaluation.

This section defines the means by which the student will demonstrate acquisition of the desired terminal capability. It is intended that this section normally not be seen by the student until he offers for examination. This section defines the measure of individual achievement for the learning unit (Morrison & Lecznar, 1966), and is the basis for prompt feedback to the student concerning the adequacy of his performance.

As mentioned earlier, the development of units has just begun. Many units are in draft form, but none is considered completed. Nevertheless, an example unit (on making contour cuts with a band saw) is shown in Appendix B as an illustration of the kind of material being constructed. Though this draft unit exhibits some of the deficiencies commonly observed in units when first sketched, it provides a reasonable example of the kind of material required for each section of the lesson plan.

Some salient characteristics. Learning units developed according to the plan for Project ABLE represent an attempt to design the conditions of learning in advance. The more common procedure, of course, is to provide the teacher with a set of objectives and ask him to select and establish appropriate conditions extemporaneously in the classroom during interaction with the student. The predesign of learning situations has several advantages over "contemporary" design, including possibilities for (1) carefully

considered choices of instructional conditions, (2) control of the quality of choice of learning conditions, (3) pretesting and revising the situations, and (4) increasing the time available to teachers for managing instruction, motivating, generalizing, and assessing (Gagné, 1965).

A second characteristic of the units is their emphasis on the student and his activity. The objective is stated in terms of student capabilities. The instructions are addressed to the student and direct the student's activity. The units usually lead the student to many activities which can be carried out individually and at the student's chosen pace. The criterion for progressing to a new unit is individual demonstration that he has achieved the objective of the current unit. This emphasis on the student is in contrast to many lesson plans which are addressed to the teacher, prescribe some of his activity and the teaching aids to be used, but prescribe little about the student's activity.

A third notable characteristic of these units is the attempt they make to enhance the student's motivation for achievement. Great care was taken to ensure that topic objectives and learning units were relevant to goals of importance to the student and to make this relevance clear to the student. The objective of the unit is stated in terms of the performance capability the student is to acquire and means are provided with each unit for determining whether that capability has been acquired. Units are relatively short affording frequent opportunity for demonstrating success. All of these provisions are intended to give purpose to the learning activity and to provide the student with reinforcement for all successful efforts.

As the development of learning units proceeds and the operating definition of the curriculum evolves, it becomes increasingly apparent that the emerging curriculum will affect the functions of teaching and of administration. Some of these effects are briefly considered next.

Effects on Teaching and Administration

Even though the development of learning units is just begun, it is clear that the trend in instructional modes is away from the lecture. The

teacher using units from Project ABLE will be called upon to talk to an assembled class of students much less often than is common in secondary schools. On the other hand, it appears that the teacher will spend much more than the usual amount of time assessing students' performances, deciding what unit students should attempt next, conducting demonstrations, conducting discussions among small groups of students, and coaching and tutoring individuals. It appears that the new curriculum will present the teachers with a less homogeneous instructional situation than is common, and that it will require of them the ability to change from one kind of activity to another both often and irregularly.

Administrative functions also are expected to undergo change in order to accommodate the new curriculum. One of the first problems to be faced is that of materials. Large amounts of curriculum material is being produced. The materials must be published, stored, and then distributed efficiently. Further, the learning units reference books, not all of which are current texts in the schools, and periodicals which must be bought. They refer the student to films which require equipment for viewing and a place and facilities for operation. The logistic problems of the curriculum are considerable.

A second administrative problem is the general one of controlling the students. Thus, in response to direction of the unit, students may need to leave an assigned room to fetch books from the library, or to go to a film viewer. Ways must be devised to permit this kind of movement without creating obstacles to learning or motivation and while retaining reasonable order. Similarly, when students are working on several different units in the same room, the teacher may need some new classroom administrative procedures to handle the movement of students, the use of materials, and the allocation of the teacher's time.

Finally, methods for reporting progress to parents and for issuing certificates and diplomas may be rather different for courses in which instruction has been thoroughly individualized. The most accurate report probably would be a listing of the things each student had demonstrated he could do. Such a report is, in fact, contemplated for vocational courses and is expected to be a useful way to communicate with potential employers about the student's capabilities.

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PLANS FOR NEXT QUARTER

The following activities are planned for the quarter ending 31 December 1966:

1. Development of learning units and proficiency measures will continue as the major technical activities of the project.
2. Procedures for evaluation of the junior high guidance program will be completed and data collection will be started.
3. Development of senior high guidance program objectives will continue.
4. The Advisory Panel will meet to review products developed to date and to consider problems in the implementation of the curriculum.

APPENDIX A

CHECKLISTS USED TO SURVEY JOBS FOR REQUIREMENTS FOR MATHEMATICS AND SCIENCE SKILLS AND KNOWLEDGE

INSTRUCTIONS FOR USE OF THE CODE SHEETS
FOR MATHEMATICAL SKILLS; A-#1 through E-#52.

For <u>each</u> job you have listed for which you will teach in your field--
--please go through the listings of A-1 up to and including E-52 and if that coded mathematical skill is needed by the student--to complete any task of that particular job---<u>encircle</u> the code as follows:

	A-10
3	A-11
2	A-12

In the column to the <u>left</u> of the encircled codes <u>only</u>, please indicate by the insertion of a 1, 2, 3, if the degree of <u>emphasis</u> required in the teaching of this skill is a:

1. small amount - go over in passing; good but not necessary.
2. average amount - good knowledge; highly desirable
3. great amount - excellent knowledge following much practice; essential

When a code such as A-10 does not apply do nothing.

SELECTED JOB TITLE_____

A-1; Addition as such.

A-2; Subtraction as such.

A-3; Multiplication as such, also large number products.

A-4; Division as such, also long division.

A-5; Involution or raising of a number to a power.

A-6; Evolution or extraction of a square root from a number.

A-7; Square root or finding by method the square root of any number.

A-8; Cube root or finding by method the cube root of any number.

A-9; Axioms i.e. equals added to equals their sums are equal or the shortest distance between two points is a straight line.

A-10; Decimals, definition and describe

A-11; Fractions, definition, place and power i.e. 231 = 200 + 30 + 1 where 200 = hundreds, 30 = tens and 1 = units.

A-13; Base Binary System - 2 digits 0 and 1; 2 =10; 3=11; 4=100

A-14; Base 3; 3=10; 4=11; 5=12; 6=20; 9=100

A-15; Base 4; 4=10; 8=20; 16=100

A-16; Base 5; 5=10; 10=20; 25=100

A-17; Base 6; 6=10; 12=20; 36=100

A-18; Base 7; 7=10; 14=20; 49=100

A-19; Base 8; 8=10; 16=20; 64=100

A-20; Base 9; 9=10; 18=20; 81=100

A-21; Base 10; See A-12 our present number system.

A-22; Base 11; 10=T; 11=10; 12=11; 21=1T; 22=20; 32=2T; 120=TT

A-23; Base 12; Duo-decimal System 10=T; 11=E; 12=10; 22=1T; 23=1E; 24=20; 100=84; 120=T0; 132=E0; 144=200; 143=EE

A-24; Slide Rule - Use of and its accuracy.

A-25; Reciprocals - Denotes different kinds of mutual relation; the reciprocal of a number is 1 divided by that number. This process generally is easy when powers of 10 are used.

A-26; Factor or factors - what are they? - Use of.

A-27; Fractions - in addition

A-28; " " subtraction

A-29; " " multiplication

A-30; " " division

A-31; Decimals - in addition

A-32; " " subtraction

A-33; " " in multiplication

A-34; Decimals - in division

A-35; Construction - bisection of an angle

A-36; Construction - perpendicular to a line point

A-37; Construction - paralled to a line

A-38; Construction - perpendicular to a line from a point not on that line - shortest distance.

A-39; Construction - perpendicular bisector of a line sgment.

A-40; Construction - An angle equal to a given angle

A-41; Consturction - draw a triangle - given three sides.

A-42; Construction - find center of an arc

A-43; Construction - find radius of an arc

A-44; Construction - divide a straight line into any number of equal parts

A-45; Construction - draw a regular polygon - multiples of three

A-46; Construction - draw a regular polygon - multiples of four

A-47; Construction - draw a regular polygon - multiples of five

MATHEMATICS

SECTION B
MEASUREMENT

SELECTED JOB TITLE_____

B-1; Metric System - know and be able to transfer into inches and feet, etc. from meters and grams etc.

B-2; Micrometer - be able to read and understand the reading.

B-3; Units - what are feet, inches, degrees, square feet, etc. Understand what dimension and know how to convert or transfor linear, area and volumetric units.

B-4; Tables - reading and understanding of any standard table.

B-5; Graph - co-ordinate in what quadrant. Understanding of a 2 dimensional graph.

B-6; Graph - pictoral - read and understanding.

B-7; Interpolation - the ability to read between table limits and to give an approximate reading in the figures of that table.

B-8; Extrapolation - the ability to read beyound the given variable limits of the table and give a good approximation.

B-9; Signed Numbers - to perform all functions with these numbers i.e. (-4)+ (+8) = +4, etc.

B-10; Number Line - show that B-9 is correct by use of this.

B-11; Pythagorean Theorem - $a^2 + b^2 = c^2$ or $x^2 ty^2 = r^2$

B-12; 3-4-5, Right triangle - recognize in any form - find 3rd side given any 2

B-13; 5-12-13, " " "

B-14; 7-24-25, " " "

B-15; 8-15-17, " " "

B-16; 9-40-41, " " "

B-17; 30° and 60° angles - construct and use in a right triangle

B-18; 45° and 90° angles - " "

B-19; 22 1/2 and 15° angles - " "

B-20; Pi = π = 3.1416

B-21; $\pi/4$ = .7854

B-22; Complementary angles - sum of 90° for any 2 angles.

B-23; Supplementary angles - sum of 180° for any 2 angles.

B-24; Fraction - 3 signs of and use of; $\left(- \frac{-N}{-D}\right)$

B-25; Protractor - measuring of an angle

B-26; Base e - logarithms.

B-27; Base 10 - logarithms (by table)

B-28; Any Base - logarithms. 2 to the 5th power = 32 or log of 32 to the base 2=5

B-29; Degree - What is a degree of an angle? What is an angle - arc degree and what it is?

B-30; Radian - What it is and degree relation.

SELECTED JOB TITLE_____

C-1; Sketching - a rough design or plan - a brief outline of facts in figures.

C-2; Graph (co-ordinate) - Use in showing relations between lines or curves, etc.

C-3; Graph (pictoral) or (circle) - Use in showing numerical relations; parts of the whole by per cent or fraction.

C-4; Ratio - comparison of 2 measures of the same unit.

C-5; Proportion - expression of equality between any two or more ratios.

C-6; Inversion of a Proportion - invert both ratios of a proportion.

C-7; Mean Alternation - alternating the 2nd and 3rd or mean terms of proportion. 2:4::5:10 - 4 and 5 are mean terms

C-8; Extreme Alternation - alternating the 1 stand 4th or extreme terms of proportion 2 and 10 in C-7.

C-9; Addition of Proportion - the adding of the denominator to the numerator and placing sum over denominator or under the numerator 2:3::4:6 goes to 2:3+2::4:6+4 or 2:5::4:10

C-10; Subtraction of Proportion - as in C-9 except we subtract, not add.

C-11; Product of Means = Product of Extremes - use of advant ages.

C-12; Variation - one of the different linear arrangements that can be made of any number of objects taken from a set. An expression of equality of 3 times 8 divided by 4=4 times 9 divided by 6 where 3 becomes 4, 8 becomes 9 and to complete the variation when 4 becomes 6.

C-13; Joint Variation - X varies jointly as y and z or x divided by y times z.

C-14; Direct Variation - X varies directly as y or x divided by y

C-15; Inverse Variation - X varies inversly as y or x times y.

C-16; Per cent - divided by 100 or some part of.

C-17; P = B x R - Given any 2 of these, solve for other in Percentage = Base times rate.

C-18; D = R x T - Given any 2 of these, solve for other in the Distance = Rate times time.

C-19; I = E x R - Electrical the Amperes = Volts times Resistance

C-20; Similitude - Ratio of one triangle of same shape to another.

C-21; Congruency - exactly same size and shape.

C-22; Equality - same area or size but not the same shape.

C-23; Line - ratio of side opposite angle to the hypotenuse.

C-24; Cosecant - ratio of hypotenuse to the side opposite the angle.

C-25; Cosine - ratio of hypostenuse to the side opposite the angle.

C-26; Secant - ratio of hypotenuse to the adjacent side of the angle

C-27; Tangent - ratio of the opposite side of the angle to the adjacent side.

C-28; Cotangent - ratio of the adjacent side of the angle to the opposite side.

C-29; Cofunctions - of complementary angles are equal. Line and Cosine

C-30; Eight Fundamental Relations - such as; Sine squared plus Cosine squared = one.

SELECTED JOB TITLE_____

D-1; Definition - Triangle
D-2; " Circle
D-3; " Ellipse
D-4; " Quadrolateral
D-5; " Rectangle
D-6; " Square
D-7; " Parallelogram
D-8; " Trapezoid
D-9; " Trapezium
D-10; " Polygon
D-11; " Regular Polygon
D-12; " Rhombus
D-13; " Parabola
D-14; " Hyperbola
D-15; Parts of - Circle
D-16; " Ellipse
D-17; " Parabola
D-18; " Hyperbola
D-19; " Trapezoids
D-20; " Quadrilaterials
D-21; " Parallelograms
D-22; " Regular Polygon
D-23; Area - Circle
D-24; " Right Triangle
D-25; " Scalene Triangle (Oblique Triangle)
D-26; " Rectangle
D-27; " Square
D-28; " Parallelogram
D-29; " Trapezoid
D-30; " Regular Polygon
D-31; " Composite Figure - by Parts
D-32; " Scaled Figure - Ratio of Areas
D-33; " Ellipse ab π = A
D-34; Lateral Area - Pyramid
D-35; " Cone
D-36; " Cylinder
D-37; " Frustum of a Cone
D-38; " Frustum of a Defined Triangular Pyramid
D-39; " Frustum of a Defined Square Pyramid

D-40; Surface Area - Cone
D-41; " Cylinder
D-42; " Sphere
D-43; " Cube
D-44; " Rectangular Solid
D-45; " Prism
D-46; " Frustum of a Cone
D-47; " Frustum of a Triangular Pyramid
D-48; " Frustum of a Square Pyramid
D-49; Volume - Sphere
D-50; " Cube
D-51; " Rectangular Solid
D-52; " Prism
D-53; " Cylinder
D-54; " Frustum of a Cone
D-55; " Frustum of a Pyramid
D-56; " Code
D-57; " Pyramid
D-58; " of a Composite Solid Figures

SELECTED JOB TITLE_____

E-1; Algebraid terms - Basic names and definitions.
E-2; Formulas - Know some - Know how to use the rest.
E-3; Inverse Functions - if addition exists - subtract that amount in equals subracted from equals, etc.
E-4; Parentheses - How to use.
E-5; Factoring - Common Factor Type
E-6; Factoring - Difference of Perfect Squares
E-7; Factoring - Trinomial Perfect Square
E-8; Factoring - Trinomial Trial and Error.
E-9; Factoring - Sum and Difference of Cubes
E-10; Factoring - Grouping Type
E-11; Factoring - Completion of the Square Type
E-12; Lowest common multiple - solving of fractional equations.
E-13; Fraction Equations - How to solve
E-14; Prime Numbers.
E-15; Polynomial Multiplication of Algebraic Expressions.
E-16; Polynomial Division of Algebraic Expressions.
E-17; Solving Linear Equations
E-18; Solving Quadratic Equations
E-19; Quadratic Formula - Develope and use.'
E-20; Solving Equations of Power greater than 2nd.
E-21; The Remainder Theorem - Solving of E-19
E-22; Functional Notation - used in solving E-19
E-23; Functional Notation - as such; $y = f(x)$
E-24; Relation - Each value of x has 2 or more values of y
E-25; Function - Each value of x has 1 and only 1 valvue in y.
E-26; Conic Sections - Relate to algebraic expres$ions
E-27; Ellipse - equations of and their use.
E-28; Circle - " "
E-29; Parabola - " "
E-30; Hyperbola - " "
E-31; Parabola - Maximum and minumum points
E-32; Simultaneous Equations - of two unknowns
E-33; Simultaneous Equations - of three unknowns
E-34; Radical Equations - Solving
E-35; Extraneous Roots - Definition and Use in E-33
E-36; Principal Value - Root of an Equation use.
E-37; Index Laws or Laws of Exponents - like bases andd exponents, etc.
E-38; The use of "i" or "j" in equations. Definition.

E-39; Imaginary Numbers - Square root of a negative unit and the product of two is equal to minus one.

E-40; Complex numbers - a plus b times i - Use of.

E-41; Boolean Algebra - Use in solving of electrical switch problems and their reduction to the simplest form.

E-42; Mixture Problems - setting up word problem equations.

E-43; Distance = Rate times time - setting up word problem equations.

E-44; Digit Type - setting up word problem equation.

E-45; Numbers Type - setting up word problems eqation - a son is twice as old as his father etc.

E-46; Coin Type - setting up word problem equation.

E-47; Work relation types - setting up word problem equation

E-48; Interest or I = PRT - setting up word problem equation

E-49; Lever Type - setting up word problem equation

E-50; Variation as Boyle's :aw pf Gases - setting up word problem equation.

E-51; Linear Distance Relation to angular distance through radians - setting up word problem equations.

E-52; Linear Velocity relation to angular velocity through radians - setting up word problem equation.

VOCATIONAL AREA_____SUB-FAMILY_____

MODERN TECHNICAL SCIENCE

Explanation of code:

B - Biology

P - Physics

C - Chemistry

T - Tools & Techniques

Example: T-2 (Measurements) is a basic concept

T-2-1 (Units of measurement) is a subject area

Evaluation: Indicate in grade column to the left the number (1,2 or 3) of the significance of the concept and subject as it pertains to your sub-families.

(1) Essential - Basic to these job areas

(2) Desirable - Useful but not essential

(3) Not required for this set of jobs but possibly contributes to growth in basic scientific attitudes.

The column to the right may be used for any comment or suggestion you may wish to contribute to the science program.

CHALLENGE OF CHANGE IN SCIENCE

Since the onset of the scientific revolution, our society is changing rapidly. This rapid change reflects upon the axioms and philosophies concerning the science curriculum.

The principle concern is not to build a vast amount of scientific knowledge for the individual, but rather, the individual having an extensive preparation in scientific disciplines. The primary disciplines are inquiry, methodology, skills and techniques. Once the disciplines are achieved the individual can make applications to pertinent vocational areas.

However, scientific training should not cease to exist once the individual has departed from formal education. It is essential that inquiry, methodolgy, skills techniques and other scientific disciplines be cultivated and intergrated with the roles that the individual interplays in the home, and in society.

As a result, when making your evaluation on the science concepts. It is essential that you consider the science curriculum in its totality, rather than the part, i.e. INDIVIDUAL - HOME - SOCIETY

*Basic science hasn't changed too much, the point of view has!

Gr. 13&12	Gr. 12	Gr. 11	Gr. 10	CODE		COMMENT
				B-1	General Concepts of Biology	
				B-1-1	Molecular evolution	
					a. Structure of atoms b. Formation of molecules and compounds c. Inorganic compounds d. Organic compounds	
				B-1-2	Cell evolution	
					a. Combinations of pertinent organic compounds b. Formation of primitive cells c. Viruses	
				B-1-3	Cell Theories	
					a. Biological history of cells b. Cell structure and function (relationship of plant and animal cells) c. Cellular reproduction	
				B-2	Life process of complex plants and animals, and their functional relationship to <u>man</u>.	
				B-2-1	Nutritional intake and breakdown (osmosis, diffusion)	
				B-2-2	Circulation of fluids	
				B-2-3	Breathing (O_2 - CO_2)	
				B-2-4	Elimination of waste	
				B-2-5	Coordination (Nervous)	
				B-2-6	Reproduction	
				B-2-7	Chemical controls	
				B-2-8	Movement (muscle)	
				B-2-9	Reproduction	
				B-3	Biology and the <u>home</u>	
				B-3-1	First Aid	
				B-3-2	Alcohol and Narcotics	
				B-3-3	Sex education	

136	12	11	10	CODE	
				B-3-4	Mental Health
				B-3-5	Infection and immunity
				B-3-6	Food consumers
				B-4	Organisms and their relationship to their environment
				B-4-1	Continuity
					a. Genetics (basic principles and gene freguency in populations)
				B-4-2	Population growth
				B-4-3	Conservation (natural and human resources)
				B-4-4	Radiation biology
				B-4-5	Health and disease
				B-4-6	Man in space
				B-4-7	Evolution of man
				C-1	Basic Concepts of Chemistry
				C-1-1	Chemistry in a changing world
				C-1-2	Chemistry and the structure of things
				C-1-3	Chemical Formulas - The language of Chemistry
				C-1-4	Functional Chemistry - Chemical Equations
				C-1-5	Solutions - Acids, Bases and Salts
				C-2	Chemistry and Man
				C-2-1	Chemistry of the Body
				C-2-2	The Chemistry of Foods
				C-2-3	The Chemistry of Disease, Drugs and Medicine
				C-2-4	The Chemistry of Clothing
				C-2-5	The Chemistry of Cosmetics
				C-2-6	The Chemistry of Photography
				C-2-7	Chemistry of Metals
				C-3	Chemistry for the Home
				C-3-1	The Chemistry of Fuels and Heating
				C-3-2	The Chemistry of Refrigeration and Air Conditioning

13&14	12	11	10	CODE	
				C-3-3	The Chemistry of Materials used in Home Construction
				C-3-4	The Chemistry for the Preservation of Food Materials
				C-3-5	The Chemistry of Cooking and Utensils
				C-3-6	The Chemistry of Design and Interior Decorating
				C-4	Chemistry for Society
				C-4-1	Production of Food
				C-4-2	Chemistry of Water Supply
				C-4-3	Chemistry of Disposal Systems
				C-4-4	Chemical effects of Alcoholism
				C-4-5	Chemistry of Space Vehicles and their Fuels
				P-1	Basic concepts of Physics
				P-1-1	Energy and matter
				P-1-2	Momentum
				P-1-3	Force and laws of motion
				P-1-4	Mass and weight
				P-1-5	Waves
				P-1-6	Vibrational motion
				P-1-7	Thermodynamics (the Laws)
				P-1-8	Electromagnetic Inductance (Lenz's Law,AC, DC generator etc.)
				P-1-9	Electromagnetic Waves
				P-1-10	Physical Optics
				P-2	Physics and Man
				P-2-1	Describing motion (Acceleration, Speed, Velocity & Time
				P-2-2	Analyzing Motion, (Acceleration, Distance and Time, falling bodies)
				P-2-3	Friction
				P-2-4	Circular motion
				P-2-5	Mechanical properties of matter
				P-2-6	Thermal properties of matter

13&14	12	11	10	COD		Comment
				P-2-7	Properties of fluids	
				P-2-8	Electricity (Charge, Coulomb's Law, Electric field)	
				P-2-9	Magnetism and magnetic forces	
				P-2-10	Capacitance and Inductance	
				P-2-11	Reflection and Refraction	
				P-3	Physics for the Home	
				P-3-1	Simple Machines	
				P-3-2	Mechanical Advantage	
				P-3-3	Equilibrium	
				P-3-4	Temperature and Heat	
				P-3-5	Heat transfer	
				P-3-6	Electric currents	
				P-3-7	Optical Instruments	
				P-3-8	Color	
				P-4	Physics for Society	
				P-4-1	The Electron	
				P-4-2	The Atom	
				P-4-3	The Nucleus	
				P-4-4	Nuclear transformations	
				P-4-5	Matter, energy and communications	
				P-4-6	Alternating current and power	
				P-4-7	Relativity and Quanta	
				P-4-8	Space exploration	
				T-1	Methodology	
				T-1-1	Exploratory Approach	
					a. Theoretical (including historical background, laws etc.)	
					b. Source materials (skills in obtaining additional information)	
					c. Experimental (performing the actual laboratory investigation)	
					1. Data collection	

13614	12	11	10	CODE		Comment
					2. Data analysis 3. Summation 4. Evaluation a. Tolerances b. Limitations c. Scientific errors	
				T-2	Measurements	
				T-2-1	Units of Measurements (Metric and English)	
					a. Foot pounds seconds b. Centineter gram second c. Newton kilogram second	
				T-2-2	Order of magnitude	
				T-2-3	Significant figures	
				T-2-4	Approximation of calculations (scientific guess)	
				T-2-5	Slide rule and powers of 10	
				T-2-6	Graphs	
				T-2-7	Algebraic techniques	
				T-2-8	Vector analysis	
				T-2-9	Random events and Probability	
				T-3	Mechanical Tools	
				T-3-1	Mechanical	
				T-3-2	Optical	
				T-3-3	Measuring	

APPENDIX B

EXAMPLE (DRAFT) LEARNING UNIT PLANS

Task No. 17
C. O. No. 15
T. O. No. 5

Type of Learning

SELECTED JOB TITLE: Metals & Machines: Machines -- Metal Sawer

CODE: Signal - Si; Stimulus-Response - SR; Chaining - Ch; Verbal Association-VA; Multiple Discrimination - MD; Concept - Co; Principle - Pr; Problem Solving - PS

LEARNING UNIT OBJECTIVE #14: To learn how to make contour cuts with a vertical band saw, following a layout.

OVERVIEW: Contour sawing refers specifically to the cutting of intricate, irregular shapes rather than to cutting off material for future processing. The ease of sawing to a line on the bandsaw, coupled with the ability of the machine to hold work to commercial tolerances, has turned the operation of this versatile machine into a production process. It is therefore necessary for a person being trained as a metal saw operator to learn the process well.

LEARNING EXPERIENCES:

A. Study basic references.

B. Answer the following questions in writing and submit to instructor for approval and/or conference.

1. Problems 1-5, p. 96, Machine Technology IV, Delmar.

C. Indicate an acceptable sequence of operations applicable to each of the below listed jobs for instructor.

D. Demonstrate and explain applications of the vertical band machine for each of the following, using the approved sequence of operations.

1. Cut previously layout contour to layout line using the frictional drag method.
2. Complete single-radius contour cuts using the disk-cutting attachment. Any given radius and material.

E. List and explain factors affecting selection of method used to cut the above contours.

SUMMARY: Contour sawing is one of the most practical and important applications of the vertical band machine. In your work as a band machine operator, you will encounter numerous jobs requiring contour cuts. It therefore becomes necessary to become well trained in the art of contour sawing to gain proper background to become a metal saw operator.

REFERENCES:

Basic--Fundamentals of Band Machining, Delmar, pp. 92-93.
Machine Technology IV, Delmar, Topic 323, pp. 95-96.

Task No. 17
C. O. No. 15
T. O. No. 5

Type of Learning	SELECTED JOB TITLE: Metals & Machines: Machines -- Metal Sawer CODE: Signal - Si; Stimulus-Response - SR; Chaining - Ch; Verbal Association-VA Multiple Discrimination - MD; Concept - Co; Principle - Pr; Problem Solving - PS

LEARNING UNIT OBJECTIVE #14 (continued)

LEARNING AIDS: Vertical band machine; Selection of band blades; Disk-cutting attachment; Previously layed out jobs; 12" steel ruler; Necessary wrenches; Bench brush; File with handle; Wiping cloth.

EXIT JOBS: All machine tool operators; Maintenance Machinist; All-round Machinist; Layout Man; Machine Setup Man; Bench Machinist; Tool and Die Maker.

Learning Unit 14

Proficiency Measures

Metal Sawer

For contour sawing, a general rule for band width selection is _____.

*A. Use the widest width that will saw the smallest radius.

B. Use the widest width consistent with feeding force requirement.

C. Use the narrowest width that will saw the largest radius.

D. Use the narrowest width that will saw the smallest radius.

Where may information be obtained relative to band width limitation to radius?

A. From mathematical calculation.

B. Using formula $BW = \frac{R}{W}$

*C. Job selector dial or chart.

D. Handbook.

For contour sawing the feed should be _____.

A. heavy and intermittent.

B. easy and intermittent.

C. heavy and steady.

*D. easy and steady.

When contour sawing to a layout, it is important to keep the layout clean. How is this done?

*A. A blower tube is provided for this.

B. Wiping with a cloth.

C. Brushing with a bench brush.

D. Blowing with your breath.

Metal Sawer

What holds the work in line when contour sawing large or heavy work?

*A. Friction between the work and table, and the downward cutting action of the band.

B. Friction between the band blade and the work in its downward cutting action.

C. Work clamping attachments must be used.

D. Pressure from the feed chain and work holding attachment.

What method of contour sawing is frequently used for small radii and intricate parts where the angle of rotation is greater than 90^{o}?

A. Contour sawing accessory method.

B. Freehand method.

*C. Frictional drag method.

D. Disk-cutting attachment method.

To speed up and simplify single-radius contour cuts the _____ is used.

A. frictional drag method

B. contour sawing accessory

*C. disk-cutting attachment

D. freehand method